Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | | | | | | Candidate Number | | | | |

Pearson Edexcel Level 3 GCE

Monday 9 June 2025

Morning (Time: 1 hour 45 minutes)

Paper reference **9PH0/02**

Physics

Advanced

PAPER 2: Advanced Physics II

You must have:
Scientific calculator and ruler
Data, Formulae and Relationships Booklet (enclosed)

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations, including units where appropriate.

Turn over ▶

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Pearson

Answer ALL questions.

All multiple choice questions must be answered with a cross in the box ☒ for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following gives the SI base units of stress?

☐ **A** $\mathrm{kg\,m\,s^{-2}}$

☐ **B** $\mathrm{kg\,m^{-1}\,s^{-2}}$

☐ **C** $\mathrm{N\,m^{-2}}$

☐ **D** Pa

(Total for Question 1 = 1 mark)

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2 Which of the following provides evidence for the particle nature of electromagnetic radiation?

☐ **A** diffraction

☐ **B** interference

☐ **C** photoelectric effect

☐ **D** polarisation

(Total for Question 2 = 1 mark)

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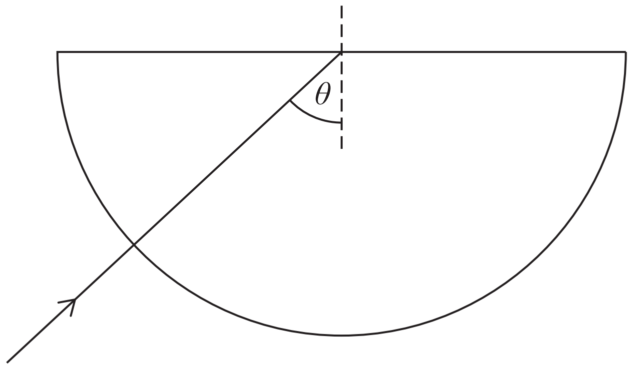
3 Light enters a semicircular glass block, as shown. The ray of light reaches the straight edge of the block at an angle of incidence θ.

The critical angle for glass is c.



Which of the following statements for light incident at the straight edge of the block is correct?

☒ **A** When θ is greater than c, then no light is reflected.

☒ **B** When θ is greater than c, then no light is transmitted.

☒ **C** When θ is less than c, then no light is reflected.

☒ **D** When θ is less than c, then no light is transmitted.

(Total for Question 3 = 1 mark)

4 Scientists believe that our universe is currently expanding. One possible fate is for the universe to reach a maximum size and then start to contract.

Which of the following descriptions of a universe with this fate is correct?

☒ **A** a closed universe

☒ **B** a critical universe

☒ **C** a flat universe

☒ **D** an open universe

(Total for Question 4 = 1 mark)

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5 X and Y are identical stars. When viewed from Earth the intensity of star X is four times the intensity of star Y.

Which of the following explanations is possible?

- ☒ **A** X is twice as far away as Y.
- ☒ **B** X is four times as far away as Y.
- ☒ **C** Y is twice as far away as X.
- ☒ **D** Y is four times as far away as X.

(Total for Question 5 = 1 mark)

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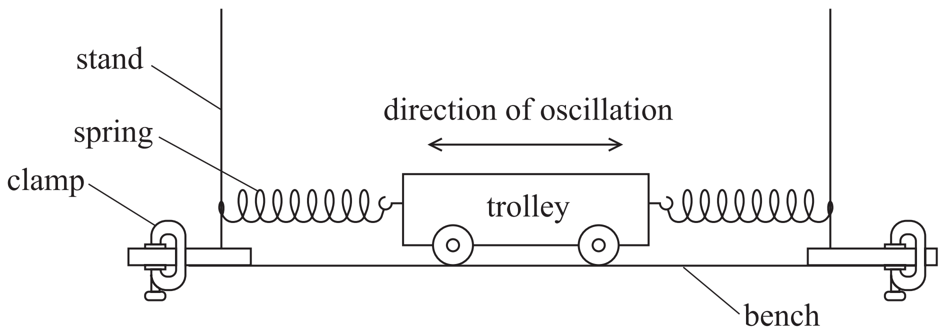
6 A trolley is attached to two springs and set into horizontal oscillation, as shown.



The kinetic energy of the trolley is E_k, and the potential energy of the trolley is E_p.

Which row of the table is correct?

		Trolley at equilibrium position	Trolley at maximum displacement
☒	**A**	E_k is a maximum	E_p is minimum
☒	**B**	E_k is a maximum	E_p is a maximum
☒	**C**	E_k is zero	E_p is a maximum
☒	**D**	E_k is zero	E_p is minimum

(Total for Question 6 = 1 mark)

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7 A small ball bearing falls slowly through a liquid at terminal velocity. The temperature of the liquid is increased.

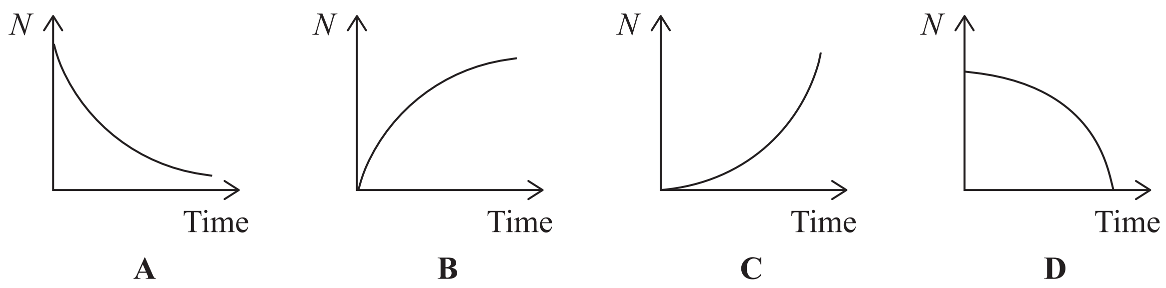
Which row of the table shows the change in viscosity of the liquid and the change in terminal velocity of the ball bearing?

		Viscosity of liquid	Terminal velocity of ball bearing
☒	**A**	increases	increases
☒	**B**	increases	decreases
☒	**C**	decreases	increases
☒	**D**	decreases	decreases

(Total for Question 7 = 1 mark)

8 Some rocks contain polonium. The polonium is radioactive, and decays to a stable isotope of lead.

Which of the following graphs shows how the number N of lead atoms produced from the decay of polonium varies with time?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 8 = 1 mark)

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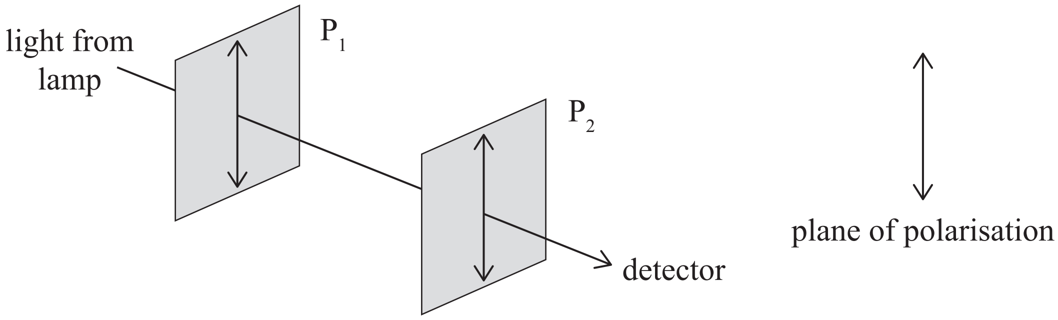
9 Light from a lamp passes through two polarising filters, P_1 and P_2, as shown. The light intensity is recorded by a detector.

The filters initially have their planes of polarisation parallel.



Both filters are rotated in the same direction.

Which row of the table gives the changes that result in the minimum intensity of light at the detector?

	Rotation of P_1 / rad	Rotation of P_2 / rad
☒ **A**	$\frac{\pi}{4}$	$\frac{\pi}{2}$
☒ **B**	$\frac{\pi}{4}$	π
☒ **C**	$\frac{\pi}{2}$	π
☒ **D**	$\frac{\pi}{2}$	$\frac{3\pi}{2}$

(Total for Question 9 = 1 mark)

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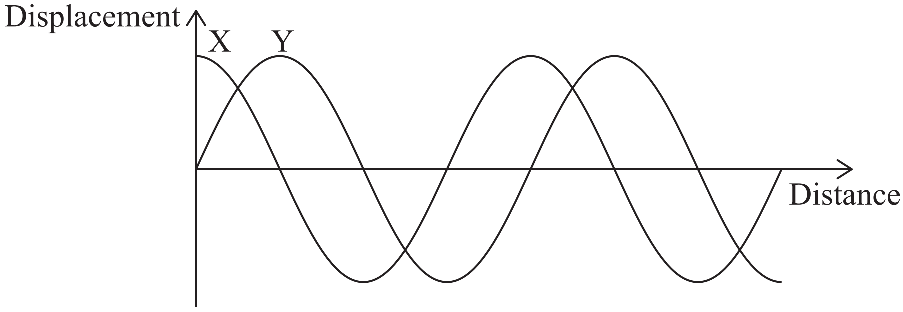
P 7 8 6 8 3 A 0 6 2 4

10 The diagram shows how displacement varies with distance for two waves, X and Y, at a particular instant. The waves are travelling to the right.



Which of the following statements describes the phase relationship between the two waves?

☒ **A** X leads Y by 90°

☒ **B** X leads Y by 180°

☒ **C** Y leads X by 90°

☒ **D** Y leads X by 180°

(Total for Question 10 = 1 mark)

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11 A spectral line with wavelength 655.88 nm is detected on Earth from the Triangulum Galaxy. The wavelength of this spectral line measured using a laboratory source is 656.28 nm.

Calculate the velocity of the Triangulum Galaxy relative to the Earth.

Magnitude of velocity = ...

Direction = ...

(Total for Question 11 = 3 marks)

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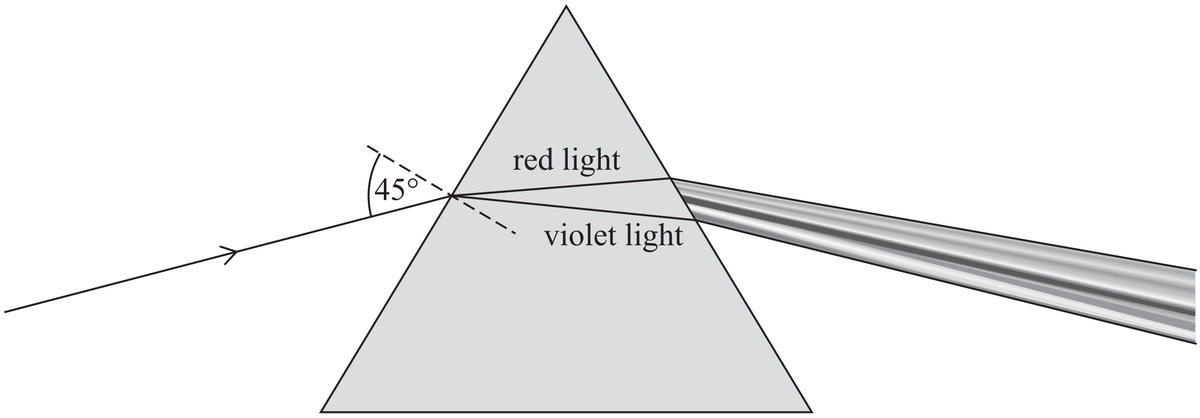
12 The image from the cover of a music album is represented below.



White light enters the prism at an angle of incidence of 45°. The light disperses and splits into a spectrum of colours as it enters the prism.

In this image the angle of refraction for violet light at the first boundary is 22°. The angle between the red light and the violet light is 11°.

Evaluate whether the angle between the red light and the violet light is accurate.

$$\frac{\text{speed of violet light in prism}}{\text{speed of red light in prism}} = 0.99$$

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(Total for Question 12 = 4 marks)

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13 A teacher demonstrated the photoelectric effect by illuminating a zinc plate with electromagnetic radiation.

When ultraviolet radiation of wavelength 320 nm was incident upon the zinc plate, electrons were emitted from the zinc surface.

When visible light of wavelength 420 nm was incident upon the zinc plate, no effect was observed.

Explain these observations. Your answer should include calculations.

work function of zinc = 3.74 eV

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(Total for Question 13 = 5 marks)

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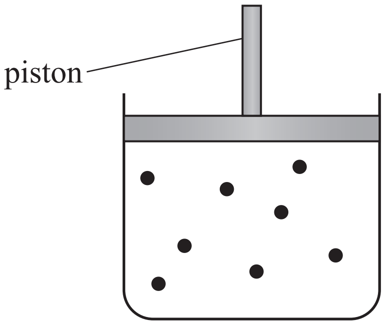
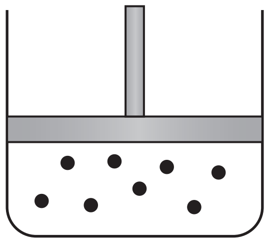
***14** Air molecules are trapped in a container by a piston, as shown.



The position of the piston is adjusted so that the volume available to the air molecules is reduced. The temperature of the air stays constant.



Explain how the pressure exerted by the air changes. You should refer to the motion of the air molecules.

(Total for Question 14 = 6 marks)

15 A pulsar is a rotating neutron star. The pulsar emits electromagnetic radiation as it rotates.

Scientists have recently detected the highest ever energy gamma ray photons received from a pulsar.

(a) The energy of one of these gamma ray photons was determined to be 2.0×10^{13} eV.

Calculate the wavelength of these gamma rays.

(4)

Wavelength = ...

(b) The pulsar is estimated to be travelling away from the Earth with a velocity of $750\,\mathrm{m\,s^{-1}}$.

State why this motion away from the Earth does not significantly affect the wavelength of radiation received at the Earth.

(1)

(Total for Question 15 = 5 marks)

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16 The closest distance from the eye where light from an object can be brought to a focus is known as the near point distance. The near point distance for a human eye is taken to be 25 cm.

A long-sighted eye has a near point distance greater than 25 cm. This may cause problems with focusing on near objects.

A converging lens can be used to correct this problem. The converging lens forms an image of a near object at the actual near point distance of the long-sighted eye.

(a) State the type of image formed by the converging lens when used to correct a long-sighted eye.

(1)

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(b) The near point distance for a long-sighted eye is 65 cm.

Calculate the power, in dioptres, of the converging lens required.

(3)

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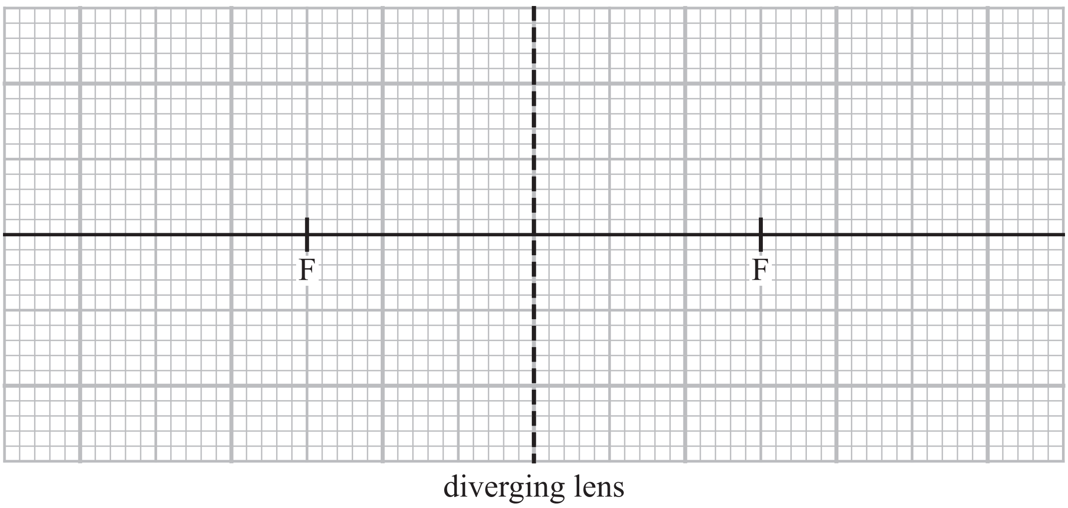
Power of converging lens = ... D

(c) A diverging lens can also be used to correct problems with eyesight.

Draw a ray diagram on the axes below to show the formation of the image of a distant object by a diverging lens. F marks the position of each principal focus of the lens.

(3)



(Total for Question 16 = 7 marks)

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17 The asteroid Bennu is in an approximately circular orbit around the Sun. Scientists consider that Bennu may collide with Earth within the next century.

(a) In 2060 Bennu will be 7.49×10^{8} m from the Earth.

(i) Show that the mass of Bennu is about 7.8×10^{10} kg.

mean radius of Bennu = 245 m
average density of Bennu = 1260 kg m^{-3}

(3)

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(ii) Calculate the magnitude of the force F between Bennu and Earth in 2060.

mass of Earth = 5.98×10^{24} kg

(2)

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F = ...

(b) The orbital time of Bennu around the Sun is 1.17 years.

Calculate the mass of the Sun.

average distance of Bennu from the Sun = 1.70×10^{11} m
mass of Bennu = 7.8×10^{10} kg
1 year = 3.15×10^{7} s

(4)

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Mass of Sun = ...

(Total for Question 17 = 9 marks)

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18 Glaciers are massive bodies of slowly moving ice. Over time, a fine sediment forms on the surface of a glacier. The sediment contains radioactive isotopes.

Caesium-137, ^{137}Cs, is a common radioisotope found in the sediment.

(a) Complete the following nuclear equation to represent the decay of caesium.

(2)

$$^{137}_{55}\mathrm{Cs} \rightarrow {}^{\cdots}_{\cdots}\mathrm{Ba} + {}^{\cdots}_{\cdots}\beta^{-} + {}^{0}_{0}\overline{\nu}_e$$

(b) The concentration of ^{137}Cs on a Norwegian glacier was investigated.

half-life of $^{137}Cs = 9.5 \times 10^{8}$ s

(i) The activity of ^{137}Cs was determined to be 2.5×10^{4} Bq per kg of sediment.

Calculate the number of atoms of ^{137}Cs in 1 kg of sediment.

(3)

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Number of atoms of ^{137}Cs = ...

(ii) Calculate the time taken for 10% of the ^{137}Cs atoms to have decayed.

(2)

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Time taken = ...

(Total for Question 18 = 7 marks)

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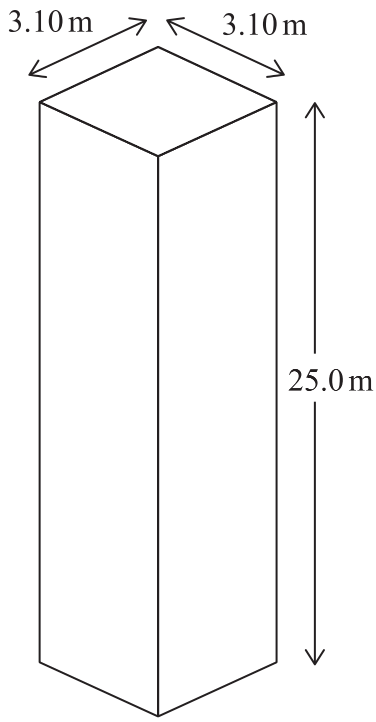
19 The photograph shows a giant ice sculpture of the Elizabeth Tower (Big Ben). The ice sculpture was installed in St Pancras station in London in 2009.

(Source: © Skye Hohmann / Alamy Stock Photo)

The ice sculpture can be approximated as a regular cuboid, as shown below.



(a) Show that the mass of the ice sculpture is about 2.2×10^5 kg.

density of ice = $920\,\text{kg}\,\text{m}^{-3}$

(2)

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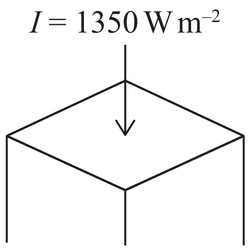
(b) (i) It is claimed that 1% of the ice would melt if the ice sculpture were in direct sunlight continuously for 12 hours. Assume that radiation, of intensity I, from the Sun is directly incident upon the top of the sculpture, as shown below.



Deduce whether this claim is correct.

initial temperature of ice sculpture = –20 °C
intensity of the Sun = $1350\,\mathrm{W\,m^{-2}}$
specific heat capacity of ice = $2.09 \times 10^{3}\,\mathrm{J\,kg^{-1}\,K^{-1}}$
specific latent heat of ice = $3.34 \times 10^{5}\,\mathrm{J\,kg^{-1}}$

(6)

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(ii) Give **two** reasons why your analysis of the situation may be incorrect.

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(Total for Question 19 = 10 marks)

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20 The photograph shows the Petronas Twin Towers in Kuala Lumpur, which are the world's tallest twin buildings.

(Source: © saiko3p/Shutterstock)

(a) Each tower is supported by 16 cylindrical concrete columns.

Calculate the stress at the base of each cylindrical concrete column.

mass of each tower = 3.0×10^{8} kg
diameter of each column = 2.4 m

(5)

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Stress at the base of each column = ...

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(b) Tall buildings sway in the wind. The design of the Petronas Towers permits safe movement of the towers.

(i) The towers were designed to permit a maximum horizontal displacement of 0.90 m at the top of the towers. The natural frequency of each tower is 0.17 Hz.

Calculate the maximum velocity at the top of one of the towers when the tower is oscillating at its natural frequency.

(3)

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Maximum velocity at the top of the tower = ...

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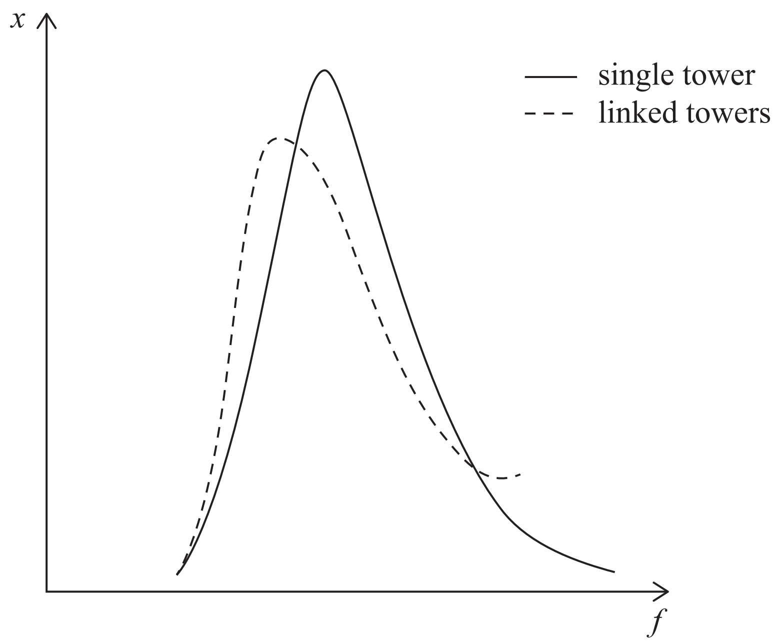
(ii) The twin towers were linked together to improve the response of the building to strong winds.

The graph below shows how the maximum displacement x varies with the frequency f for a single tower and for two linked towers.



Explain the behaviour of a single tower compared with the behaviour of the linked towers.

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(Total for Question 20 = 11 marks)

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21 All objects with a temperature above absolute zero emit a spectrum of electromagnetic radiation.

(a) State what is meant by absolute zero.

(1)

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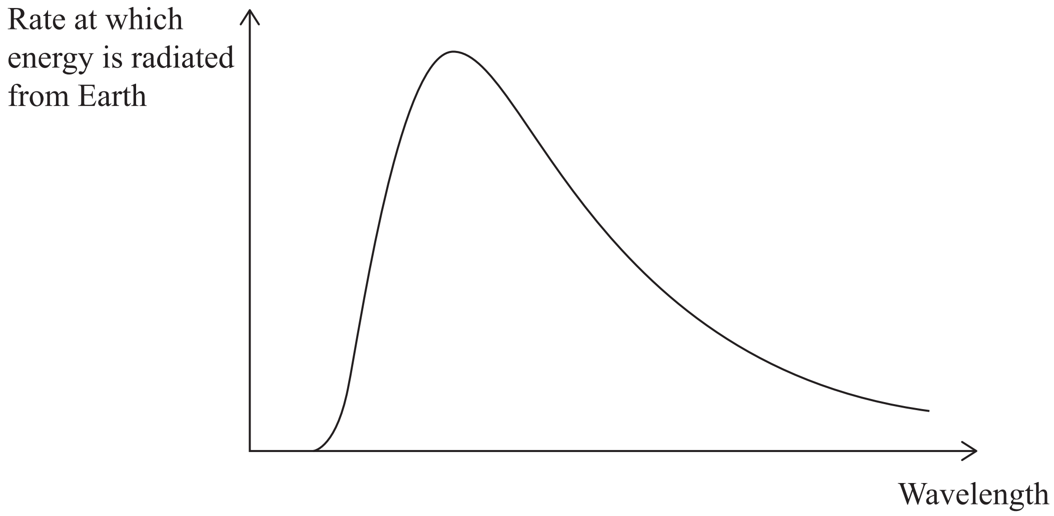
(b) The graph shows how the intensity of radiation emitted by the Earth varied with wavelength in 2020.



Explain the differences between this graph and a graph representing the emission of radiation by the Earth in 2050. Assume that the average global temperature increases over time.

(4)

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(c) At the end of the 19th century, Wien investigated the radiation emitted by hot objects and formulated a law.

The table shows data for some stars.

Star	λ_{max} / nm	T / K
Bellatrix	132	21 500
Rigel	245	11 600
Sirius	287	9910

Deduce whether Wien's law is confirmed by this data.

(3)

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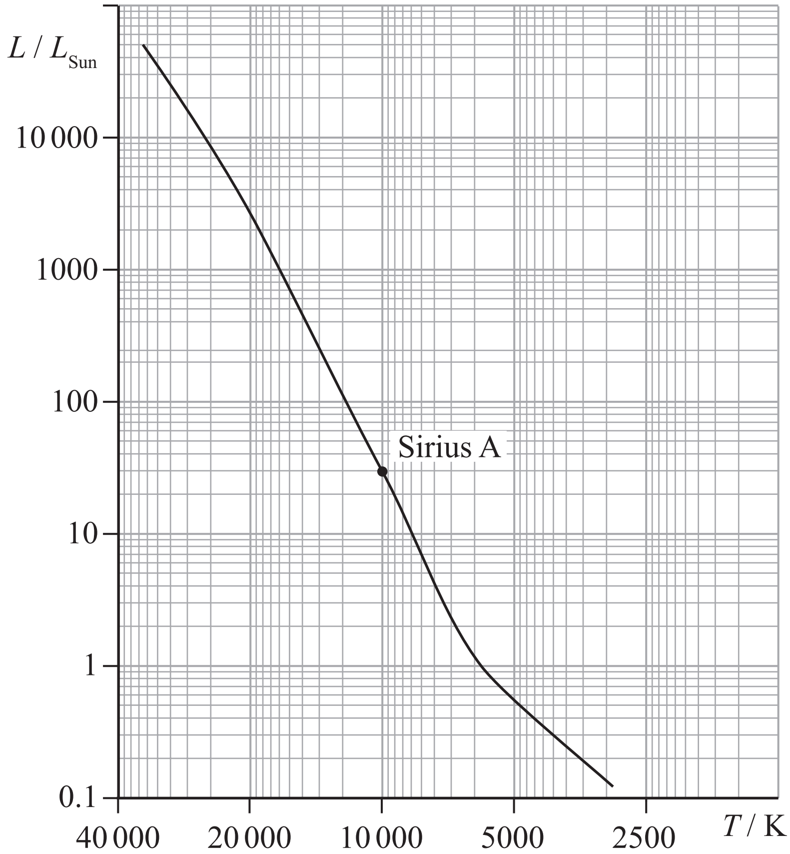
(d) The Hertzsprung–Russell diagram below shows part of the main sequence of stars. The star Sirius A is marked on the diagram.



On a website it states that the radius of Sirius A is twice the radius of the Sun.

Deduce whether this statement is correct.

radius of the Sun = 6.96×10^8 m
surface temperature of the Sun = 5800 K

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(Total for Question 21 = 13 marks)

TOTAL FOR PAPER = 90 MARKS

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Pearson Edexcel Level 3 GCE

Monday 9 June 2025

Morning (Time: 1 hour 45 minutes)

Paper reference **9PH0/02**

Physics

Advanced

PAPER 2: Advanced Physics II

Data, Formulae and Relationships Booklet
Do not return this Booklet with the question paper.

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$	
Coulomb law constant	$k = \dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \text{kg}$	

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

moment of force = Fx

Momentum

$$p = mv$$

Work, energy and power

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

Electric circuits

Potential difference

$$V = \frac{W}{Q}$$

Resistance

$$R = \frac{V}{I}$$

Electrical power and energy

$$P = VI$$

$$P = I^2R$$

$$P = \frac{V^2}{R}$$

$$W = VIt$$

Resistivity

$$R = \frac{\rho l}{A}$$

Current

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nqvA$$

Materials

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$$F = 6\pi\eta rv$$

Hooke's law

$$\Delta F = k\Delta x$$

Young modulus

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

$$\Delta E_{el} = \tfrac{1}{2}F\Delta x$$

Waves and particle nature of light

Wave speed

$$v = f\lambda$$

Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

Intensity of radiation

$$I = \frac{P}{A}$$

Power of a lens

$$P = \frac{1}{f}$$

$$P = P_1 + P_2 + P_3 + \ldots$$

Thin lens equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Magnification for a lens

$$m = \frac{\text{image height}}{\text{object height}} = \frac{v}{u}$$

Diffraction grating

$$n\lambda = d \sin \theta$$

Refractive index

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$n = \frac{c}{v}$$

Critical angle

$$\sin C = \frac{1}{n}$$

Photon model

$$E = hf$$

Einstein's photoelectric equation

$$hf = \phi + \tfrac{1}{2}mv^2_{max}$$

de Broglie wavelength

$$\lambda = \frac{h}{p}$$

Further mechanics

Impulse

$$F\Delta t = \Delta p$$

Kinetic energy of a non-relativistic particle

$$E_k = \frac{p^2}{2m}$$

Motion in a circle

$$v = \omega r$$

$$T = \frac{2\pi}{\omega}$$

$$F = ma = \frac{mv^2}{r}$$

$$a = \frac{v^2}{r}$$

$$a = r\omega^2$$

$$F = mr\omega^2$$

Fields

Coulomb's law

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$$

Electric field strength

$$E = \frac{F}{Q}$$

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$E = \frac{V}{d}$$

Electric potential

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

Capacitance

$$C = \frac{Q}{V}$$

Energy stored in a capacitor

$$W = \tfrac{1}{2}QV$$

$$W = \tfrac{1}{2}CV^2$$

$$W = \frac{1}{2}\frac{Q^2}{C}$$

Capacitor discharge

$$Q = Q_0 e^{-t/RC}$$

$$I = I_0 e^{-t/RC}$$

$$V = V_0 e^{-t/RC}$$

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

In a magnetic field

$$F = BIl \sin\theta$$

$$F = Bqv \sin\theta$$

Faraday's and Lenz's laws

$$\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$$

Root-mean-square values

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

Nuclear and particle physics

In a magnetic field

$$r = \frac{p}{BQ}$$

Thermodynamics

Heating

$$\Delta E = mc\Delta\theta$$

$$\Delta E = L\Delta m$$

Molecular kinetic theory

$$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$$

$$pV = \frac{1}{3}Nm\langle c^2\rangle$$

Ideal gas equation

$$pV = NkT$$

Stefan-Boltzmann law

$$L = \sigma AT^4$$

$$L = 4\pi r^2\sigma T^4$$

Wien's law

$$\lambda_{max}T = 2.898 \times 10^{-3}\ \text{m K}$$

Space

Intensity

$$I = \frac{L}{4\pi d^2}$$

Redshift of electromagnetic radiation

$$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$$

Cosmological expansion

$$v = H_0 d$$

Nuclear radiation

Mass-energy

$$\Delta E = c^2\Delta m$$

Radioactive decay

$$A = \lambda N$$

$$\frac{dN}{dt} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$N = N_0\,e^{-\lambda t}$$

$$A = A_0\,e^{-\lambda t}$$

Gravitational fields

Gravitational force

$$F = \frac{Gm_1m_2}{r^2}$$

Gravitational field strength

$$g = \frac{Gm}{r^2}$$

Gravitational potential

$$V_{grav} = \frac{-Gm}{r}$$

Oscillations

Simple harmonic motion

$$F = -kx$$

$$a = -\omega^2 x$$

$$x = A\cos\omega t$$

$$v = -A\omega\sin\omega t$$

$$a = -A\omega^2\cos\omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

END OF DATA, FORMULAE AND RELATIONSHIPS LIST

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